MiniBooNE: Current Status

Fernanda G. Garcia, Fermilab
URA visit, March 14, 2003

Outline

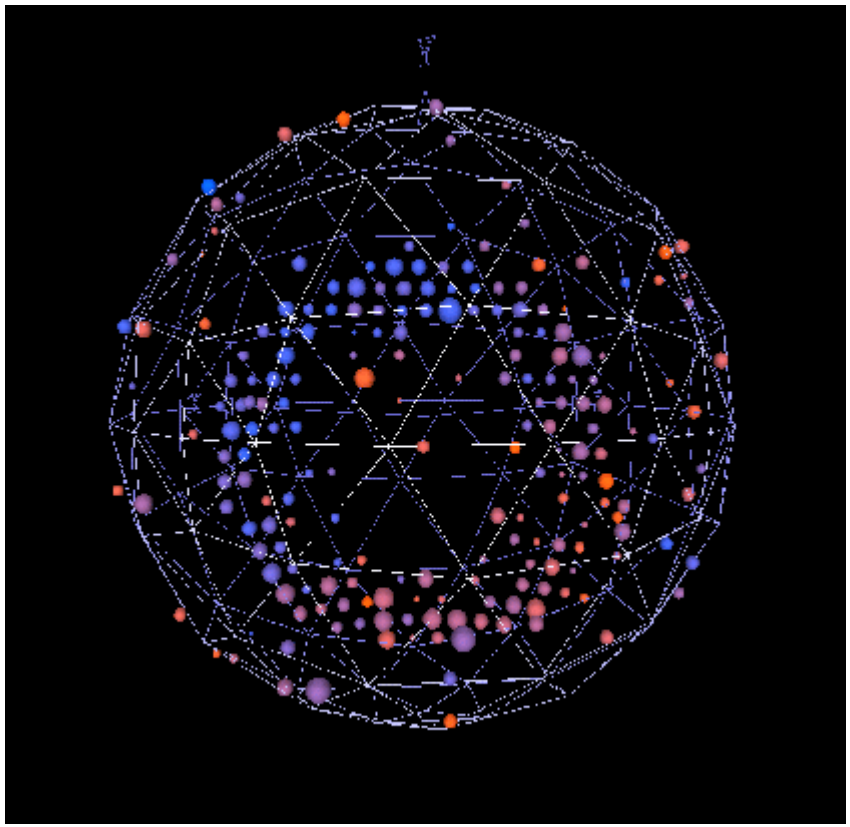
Physics motivation

Beamline performance

Detector performance

First look at the data

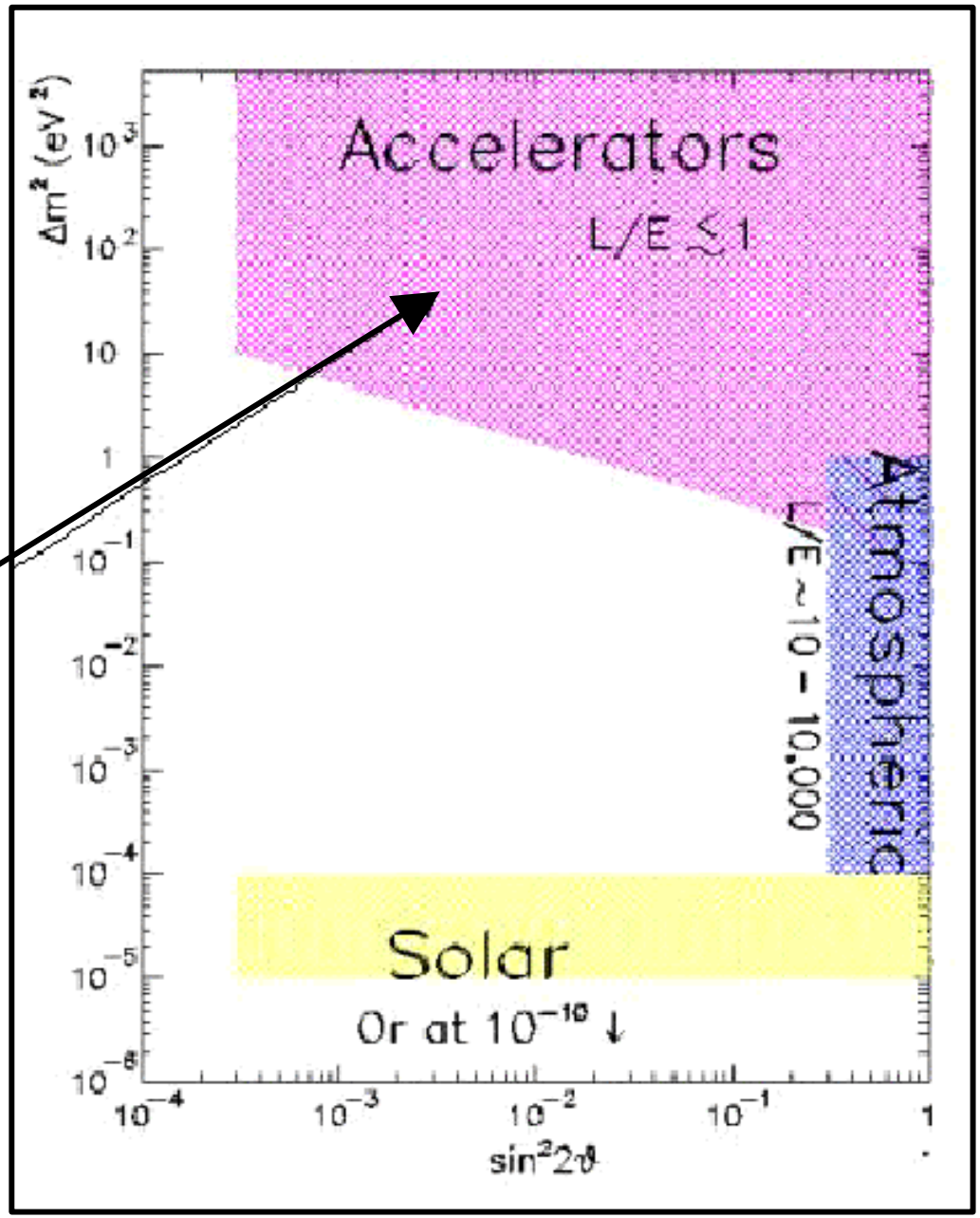
Conclusions



Search for neutrino oscillations

$\nu_\mu \rightarrow \nu_e$ at high Δm^2

LSND signal region
KARMEN II
MiniBooNE

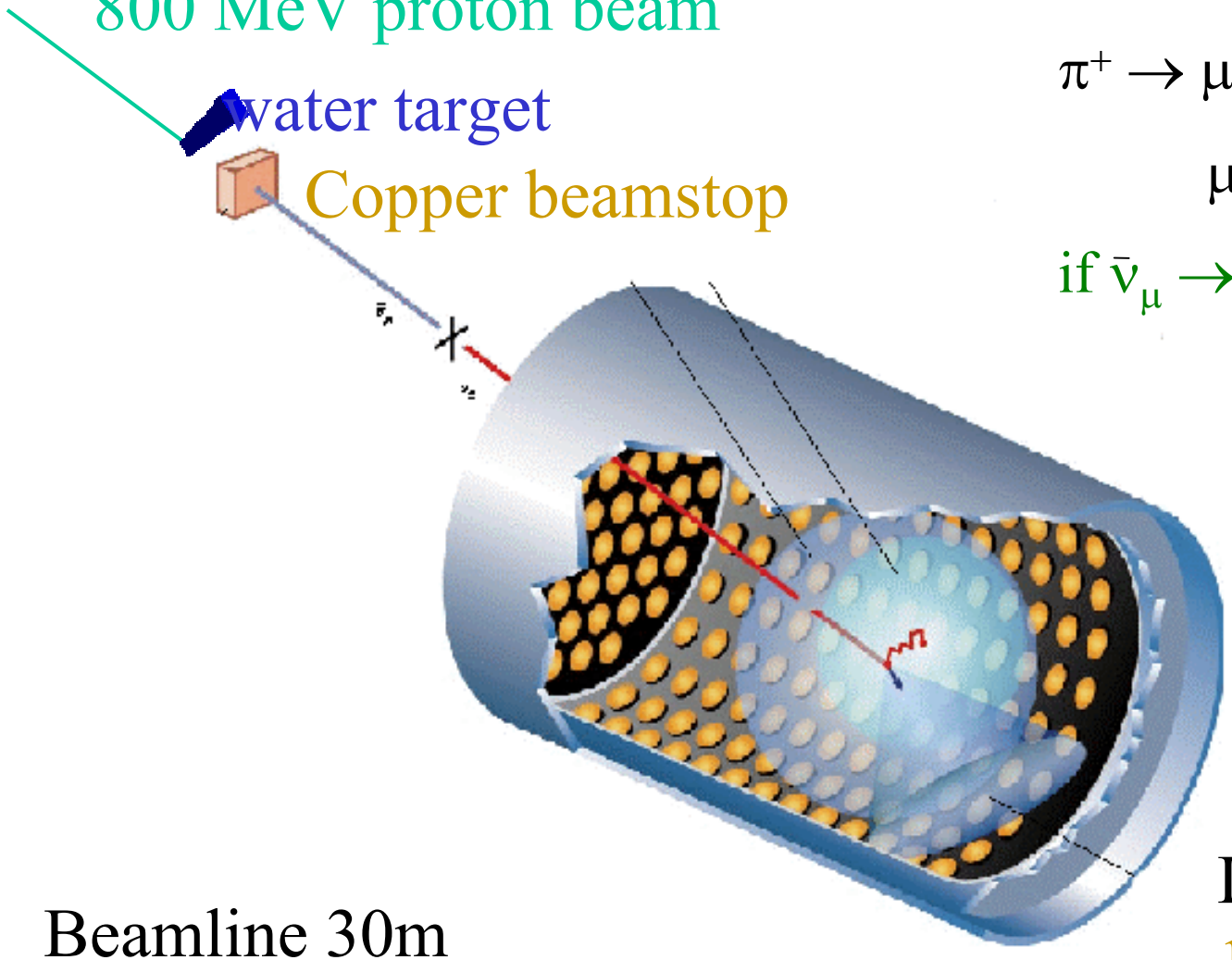


The LSND Experiment: $\bar{\nu}_\mu \rightarrow \bar{\nu}_e$

800 MeV proton beam

water target

Copper beamstop



$\pi^+ \rightarrow \mu^+ \upsilon_\mu$

$\mu^+ \rightarrow e^+ \bar{\nu}_\mu \nu_e$

if $\bar{\nu}_\mu \rightarrow \bar{\nu}_e$

$\bar{\nu}_e p \rightarrow e^+ n$

$n p \rightarrow d \gamma$ (2.2 MeV)

Beamline 30m

Neutrino energy

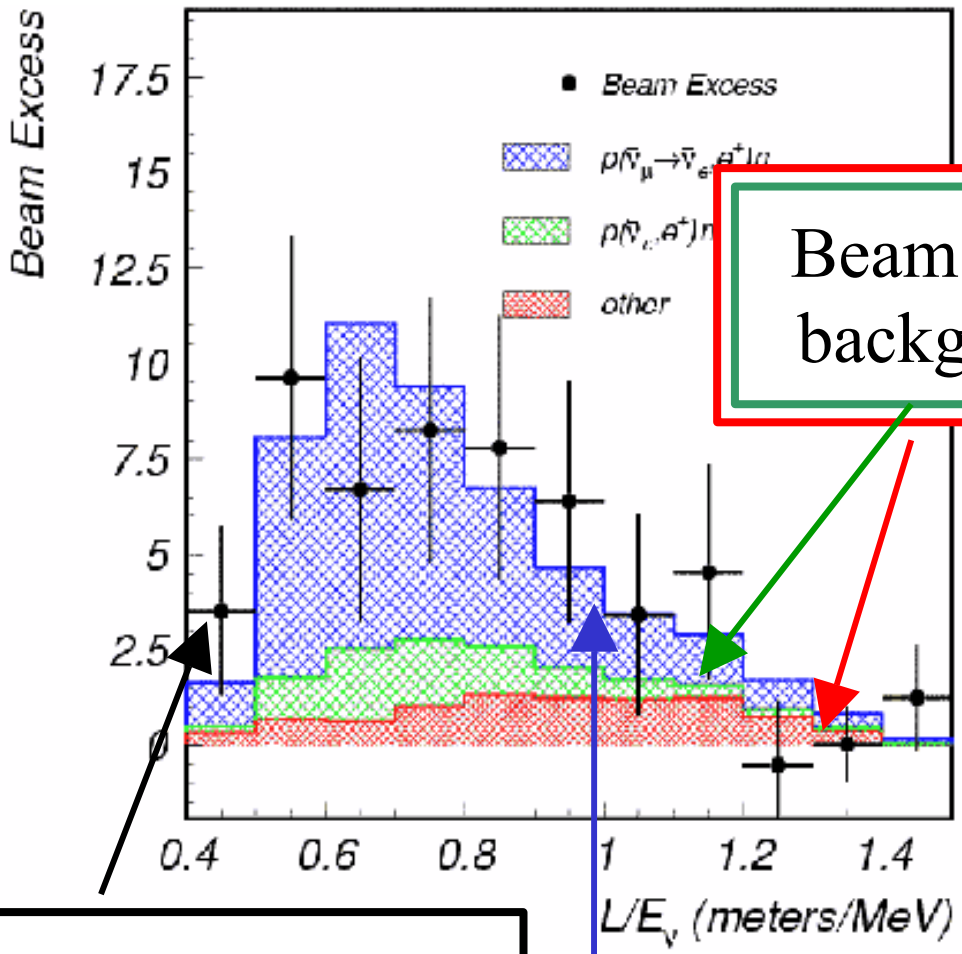
20-55 MeV

L/E = 1m/MeV

167 tons of mineral oil

1280 photomultipliers

LSND Result

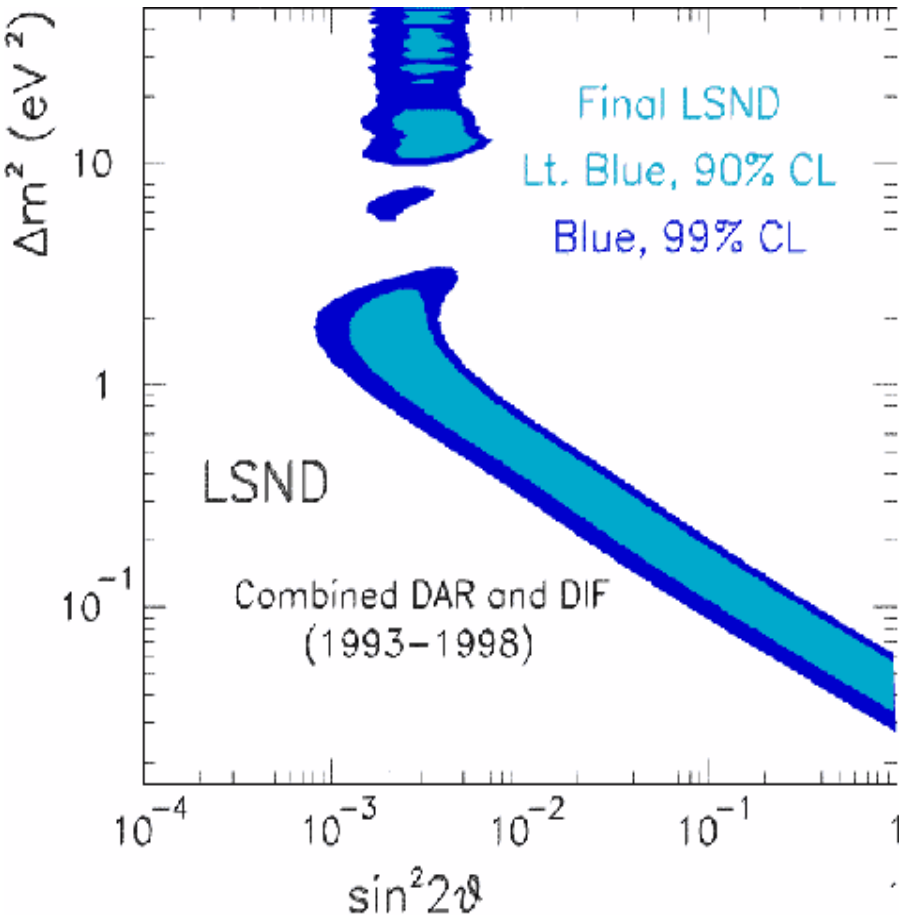


Beam related backgrounds

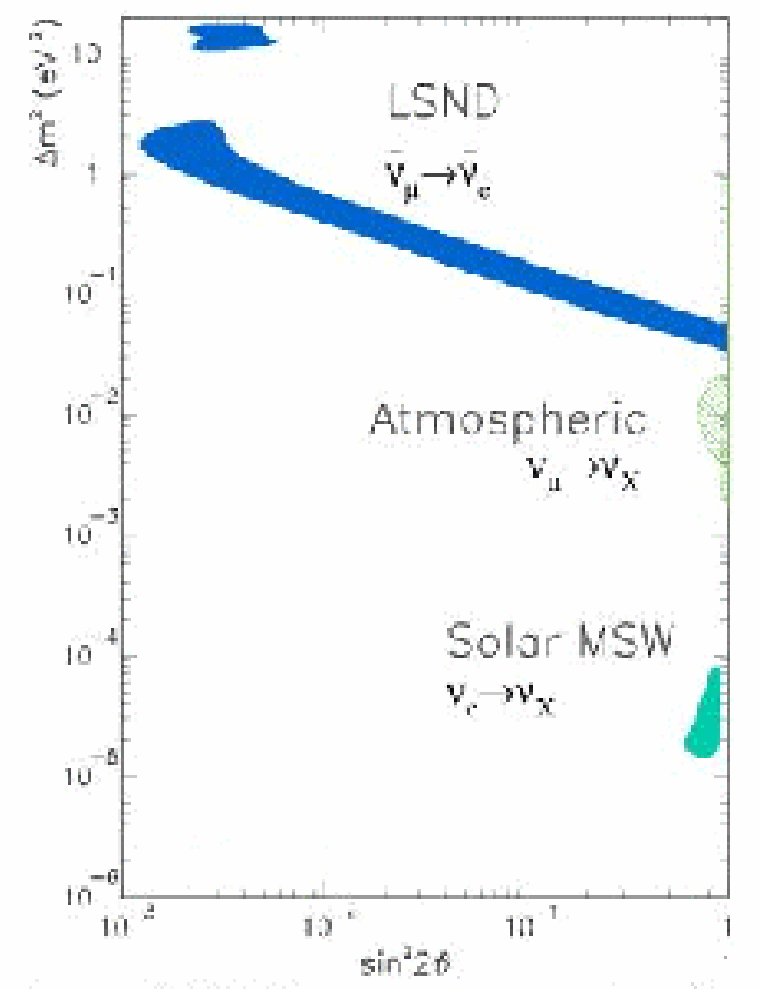
Data points after background subtraction

Expectation for oscillation

- Signal above background
  87.9 ± 22.4 ± 6.0 events
- Oscillation probability
  (0.264 ± 0.067 ± 0.045) %



Neutrino Oscillations Scenario



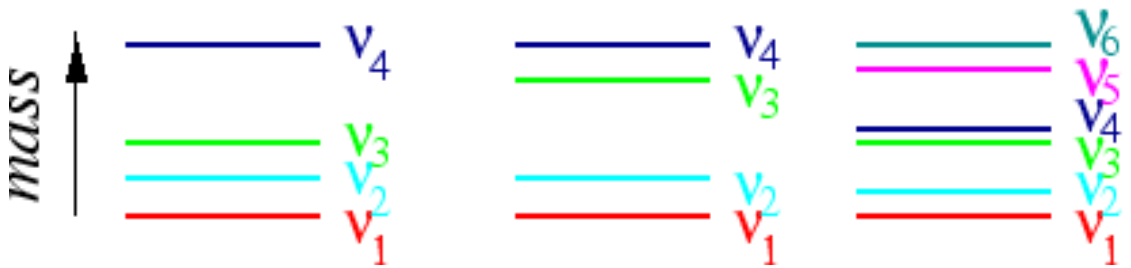
Needs confirmation

MiniBooNE

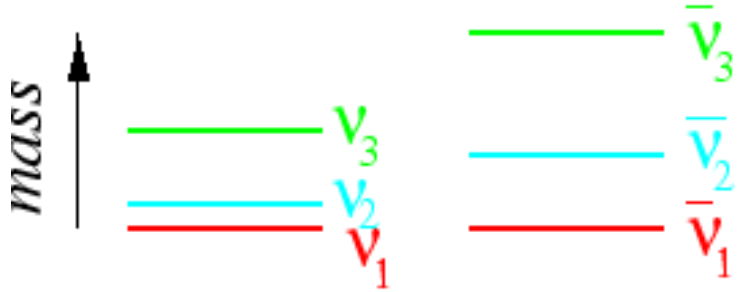
3 separated Δm^2 regions

interesting situation…

add a 4th neutrino (or more)



… or other explanations like



~~CPT~~

(Barenboim *et.al.(*Phys.Lett.B534:106.2002)

MiniBooNE

- High statistics

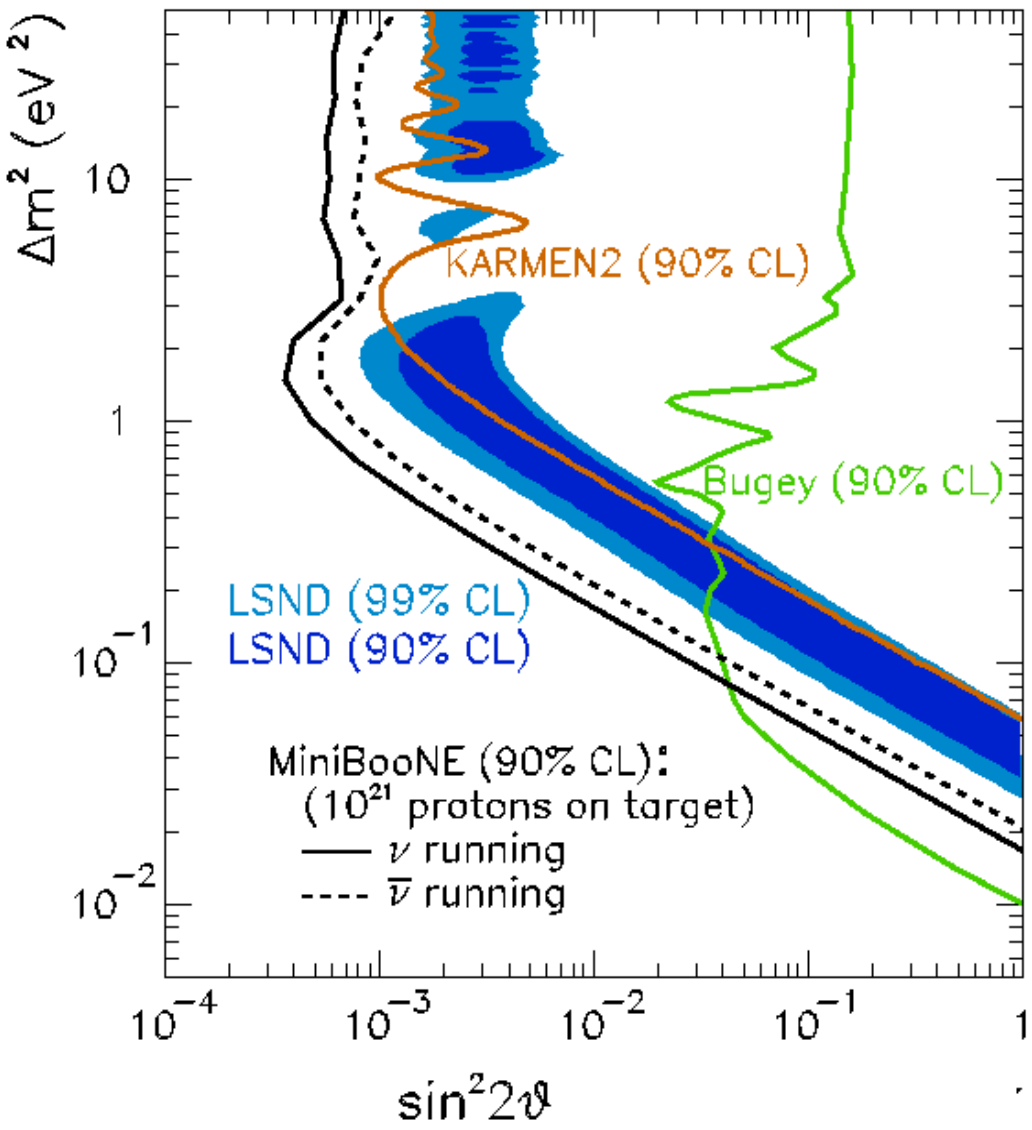
  x10 more than LSND

- Different systematics

different backgrounds and event signatures

- High flux ν_μ beam

  with well understood ν_e component



Confirm or refute LSND signal at > 5σ

The BooNE Collaboration

62 scientist from 13 institutions

2 Undergraduate institutions

9 Graduate institutions

2 National laboratories

Y.Liu, I.Stancu
University of Alabama

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Bucknell University

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University of California, Riverside

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T.Hart, E.D.Zimmerman
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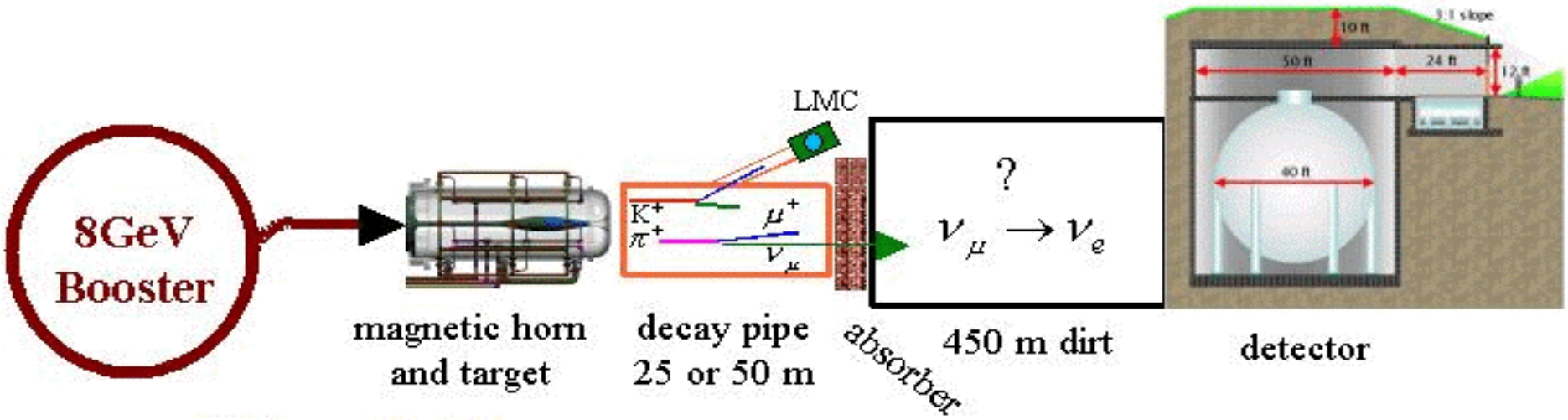
The MiniBooNE beamline



8 GeV protons from the FNAL Booster

strikes a Be target

producing mesons decay

neutrinos traverse 450 m of dirt

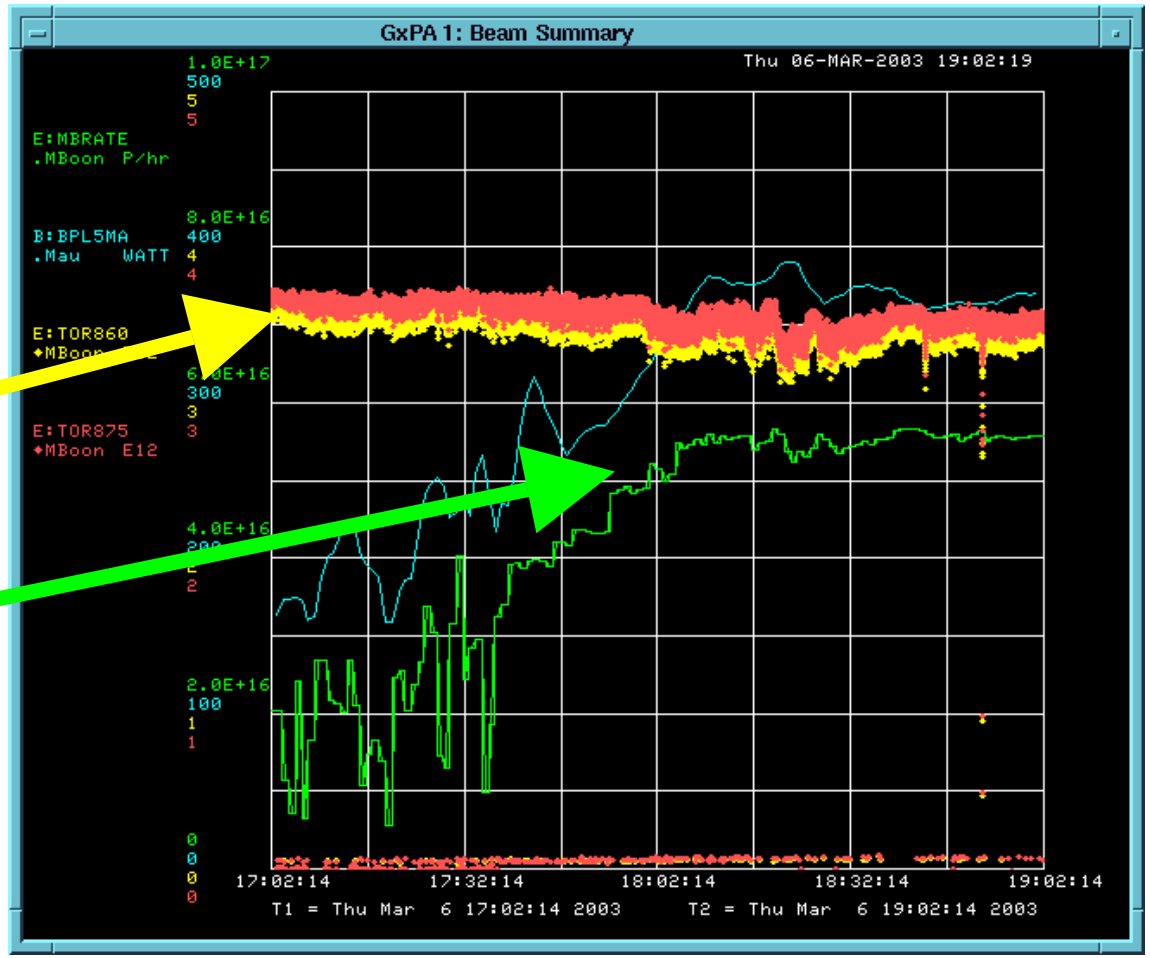
reaching the detector

Exciting time for the Booster

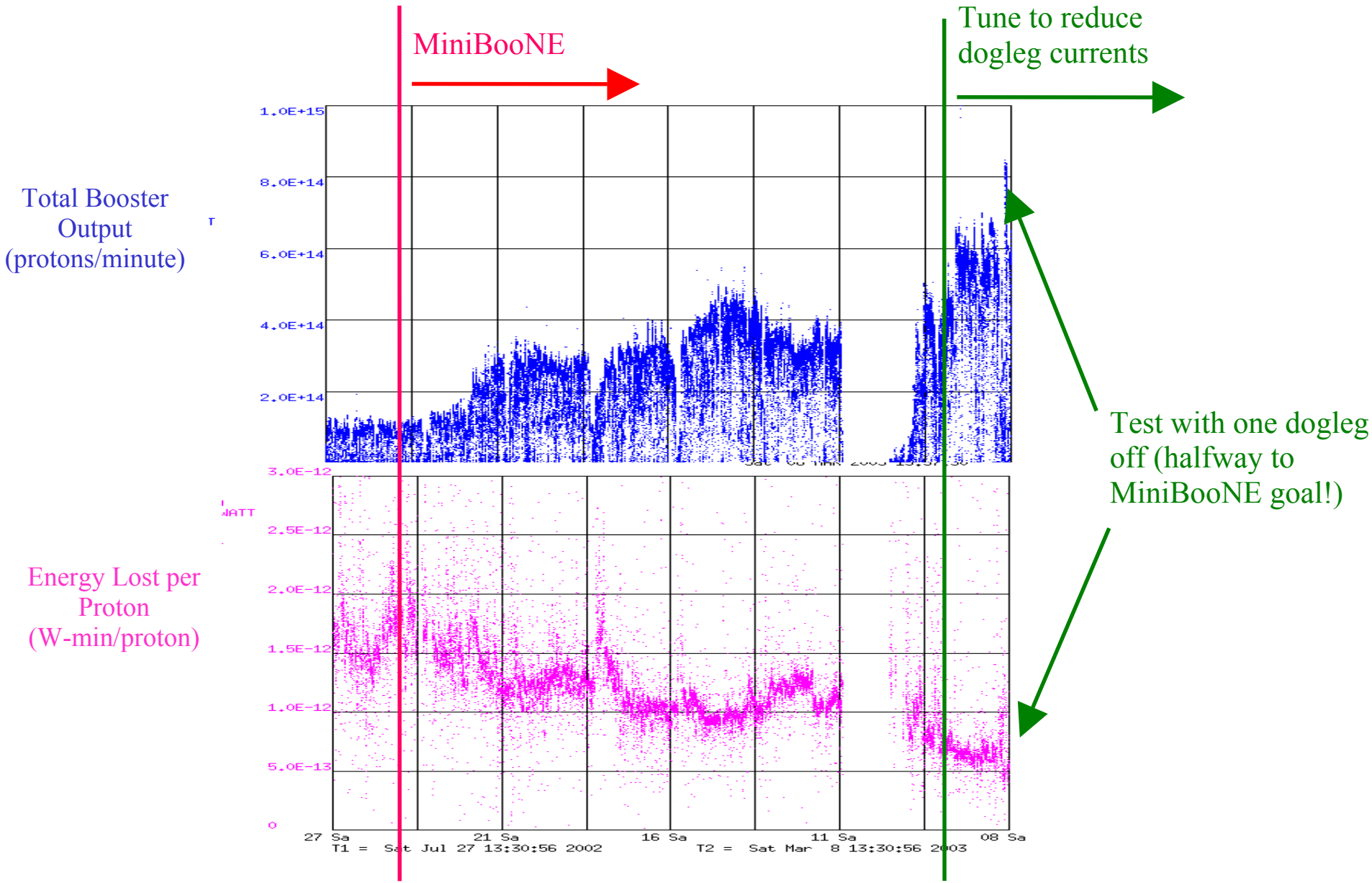
- Many improvements happened since August'02
- Dedicated study periods have enlightened our understanding of the machine
- New record achieved on February 06 after lifting up extraction septum magnet

3.5E12 protons/pulse

5.65E16 protons/hour

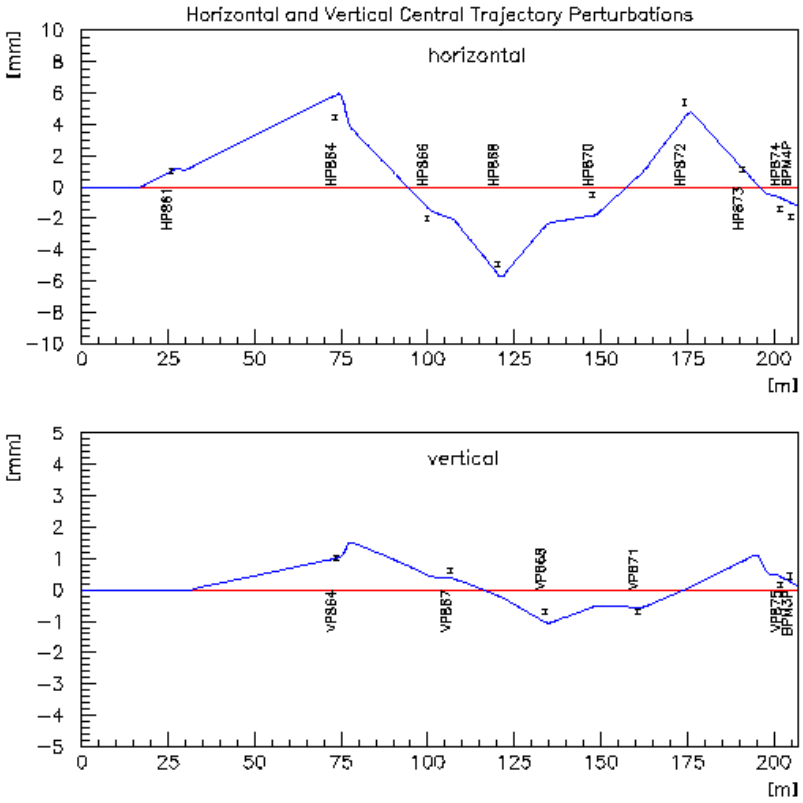


Booster performance



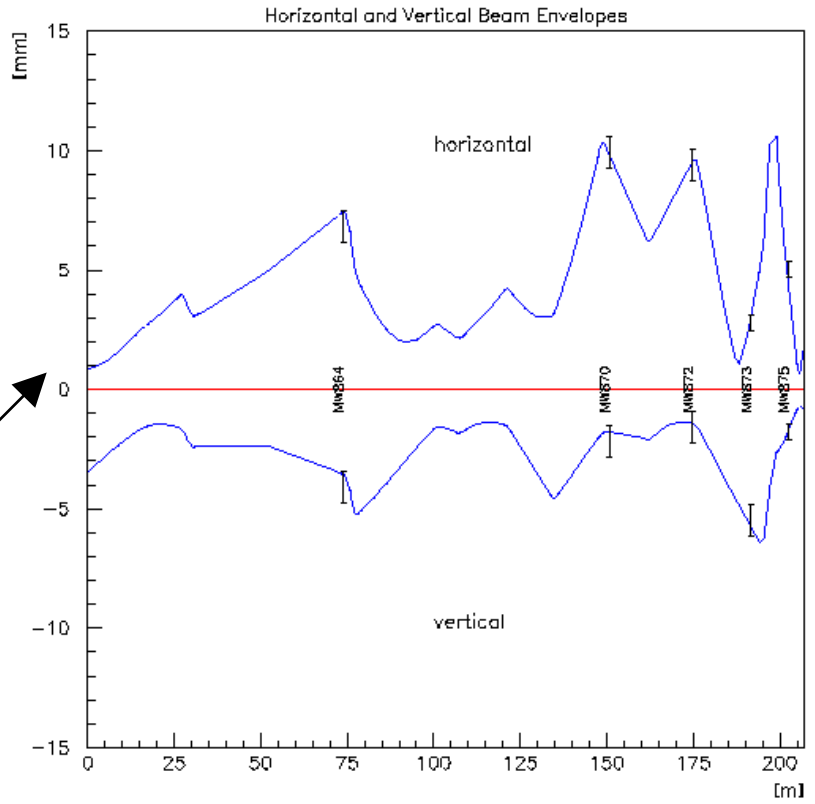
Beamline performance

We understand our beam optics



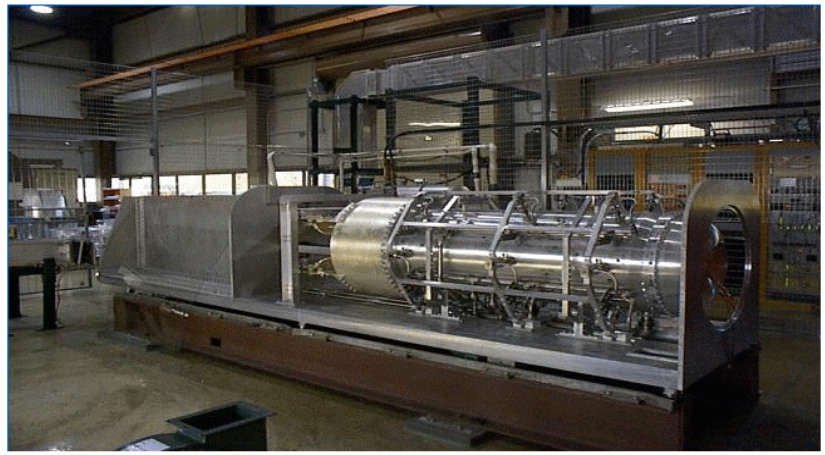
Measured and predicted changes of central trajectory along beamline

Calculated beam envelope with measurements overlayed



Horn and target system

Current: 170 KA
Rep rate: 5 Hz
Design lifetime: 200 million pulses
Up to now: 9.6 million pulses
Toroidal magnetic field focuses positive particles (ν mode)
Can switch polarity to focus negative particles ($\bar{\nu}$ mode)



- 71 cm long Be target
- Resides inside the horn
- π production off target was measured at HARP (CERN) (20.6 million triggers)

Understanding beam backgrounds

Backgrounds are mis-id of
μ's and π's
and intrinsic ν_e in the beam

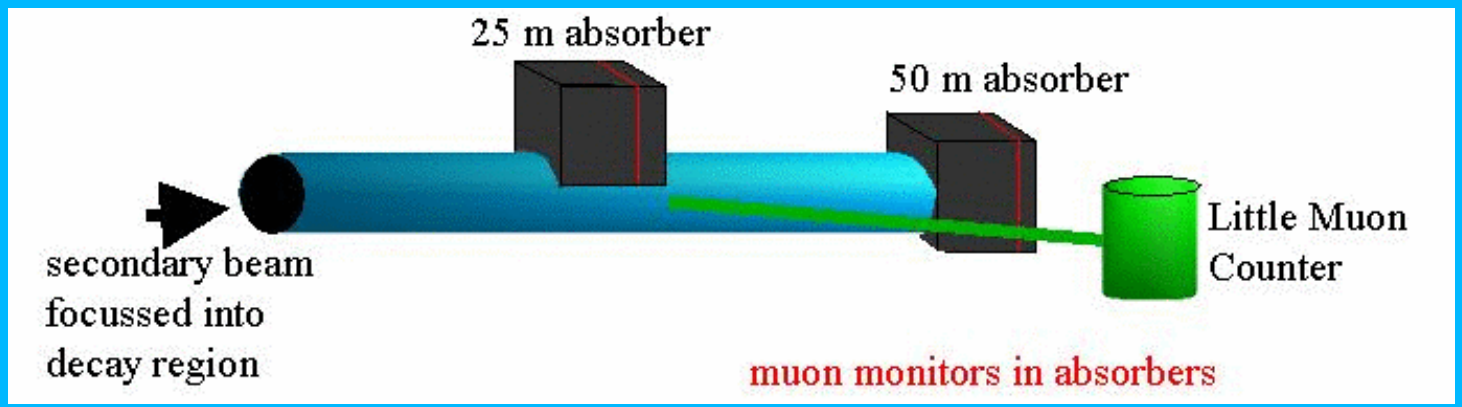
- Intrinsic ν_e's from μ decays

  Signal and background behave differently
  by varying the length of decay pipe

  Signal proportional to L_{decay}
  Background proportional to L^2_{decay}

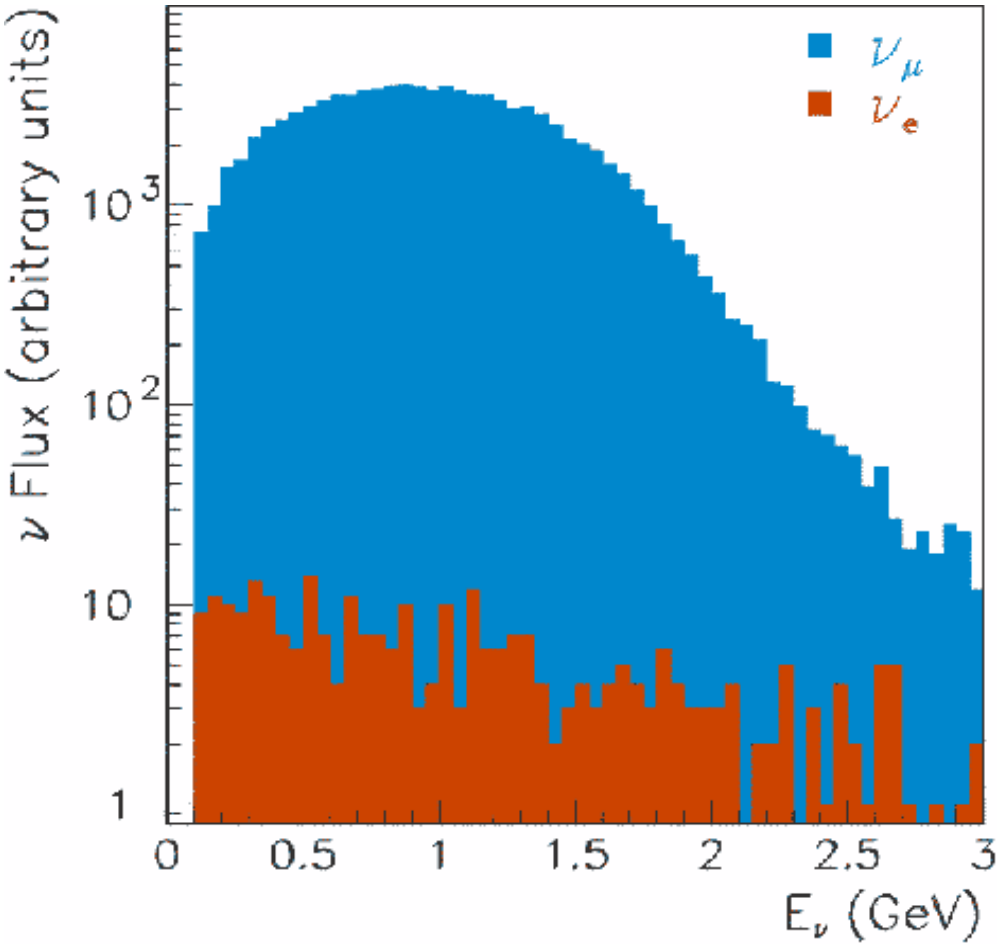
- Intrinsic ν_e's from Kaons decay (K^+,K_L)

  Little muon counter



Neutrino flux at the detector

L/E ~ 1m/MeV



Flux estimate is crucial

8 GeV protons on Be

$p + Be \rightarrow \pi^+, K^+, K^0_L$

yields a high ν_μ beam

$\pi^+ \rightarrow \mu^+\nu_\mu$

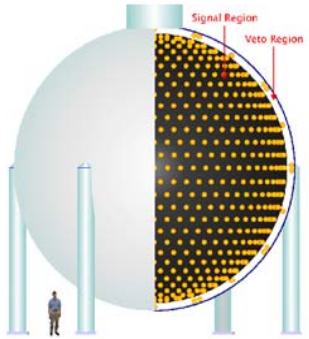
$K^+ \rightarrow \mu^+\nu_\mu$, $K_L{}^0 \rightarrow \pi^- \mu^+\nu_\mu$

with low ν_e component

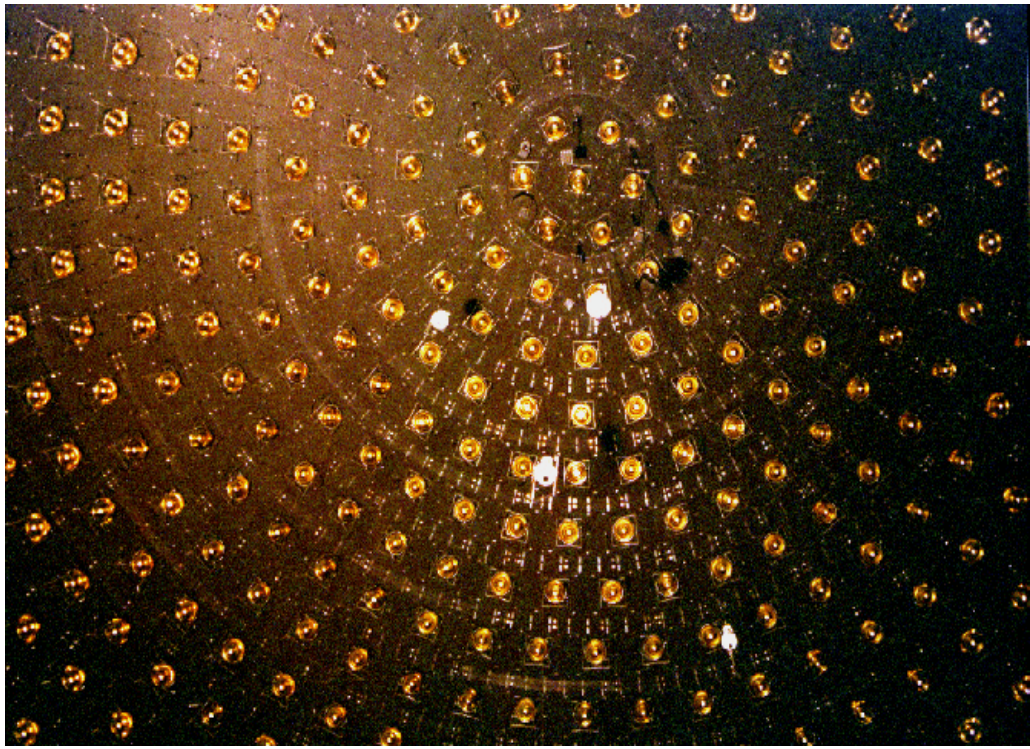
$\mu^+ \rightarrow e^+\nu_e\bar{\nu}_\mu$

$K^+ \rightarrow \pi^0 e^+\nu_e$, $K_L{}^0 \rightarrow \pi^- e^+\nu_e$

MiniBooNE Detector



- 12 m spherical stell tank
- 250,000 gallons of pure mineral oil
- Total volume: 800 tons
  Fiducial volume: 445 tons
  (5m radius)
- 1280 PMT's in the detector region
  10% photocathode coverage
- 240 PMT's in the veto region



Detector *reminiscence*

Last tube installed
October 19, 2001
(8 months total)

First oil railcar delivered
in December'01
(5 months total)

Topping off
detector in
June 24th 02

Annotate This Entry
Date Created: Sunday, August 25, 2002 12:15:12 AM CDT
Date Saved: Sunday, August 25, 2002 12:44:08 AM CDT
Category - Topic - sequence number: Shifts/Shifts - Shift_General_Log - 760
Operator(s): Fernanda Garcia
Keyword(s): :SHIFTS:

We got out FIRST BEAM on Target @ 10:34 P.M., August 24, 2002!!!!!!!!
See the MiniBooNE beamline logbook for more details and cool plots.
First Run number: 1746

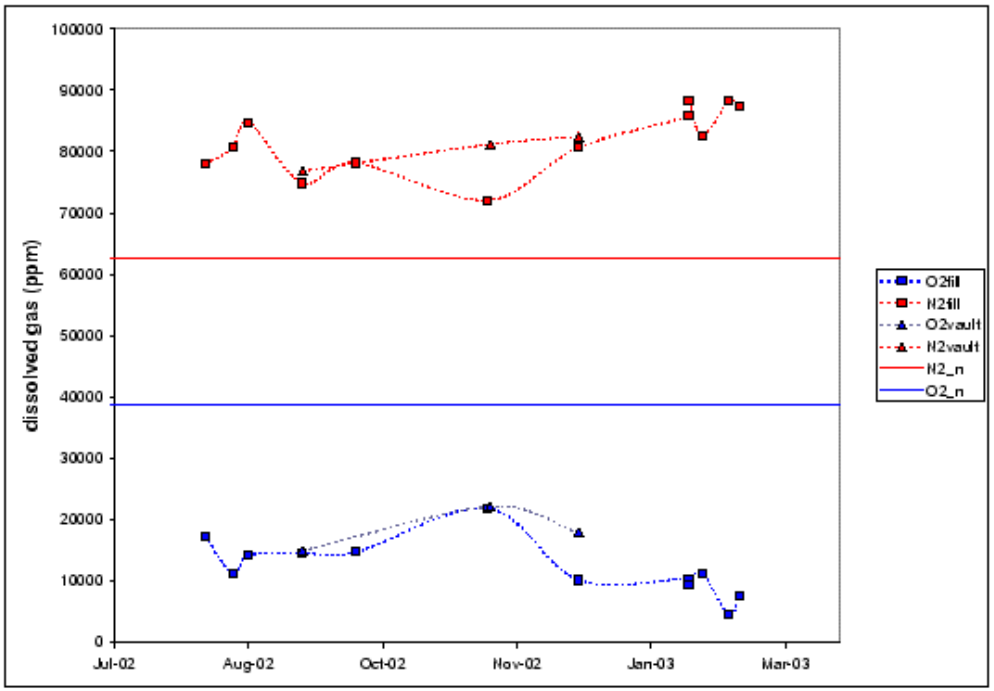
Congratulations everybody!

Monitoring the oil

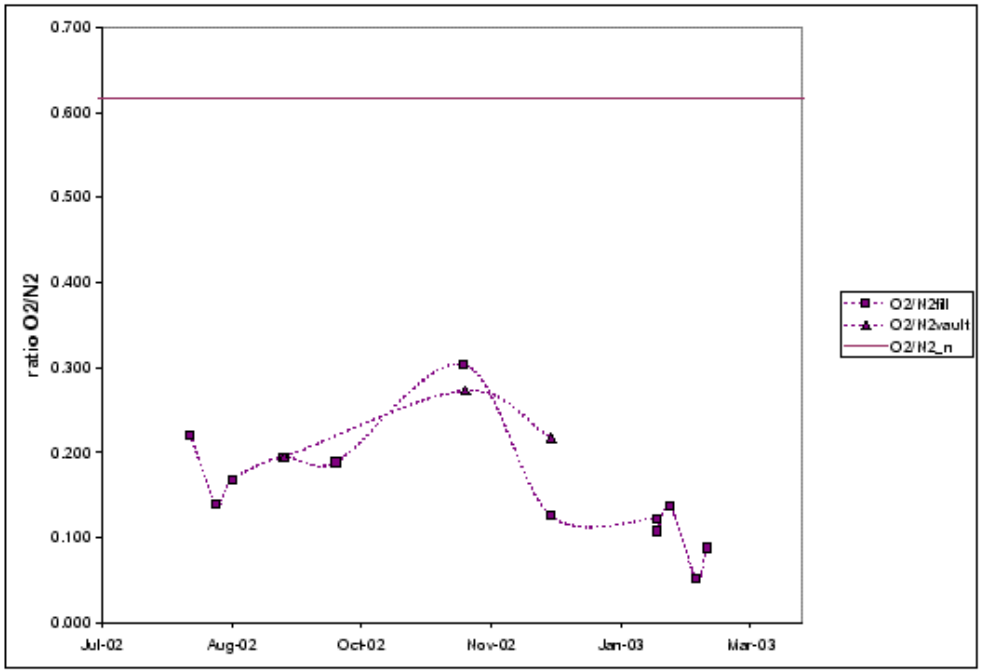
- Oil samples are taken regularly
- Attenuation length: $\langle L_{att} \rangle = 25.06 \pm 1.9\text{m}$

Oil samples are tested for oxygen on a regular basis

Dissolved gas



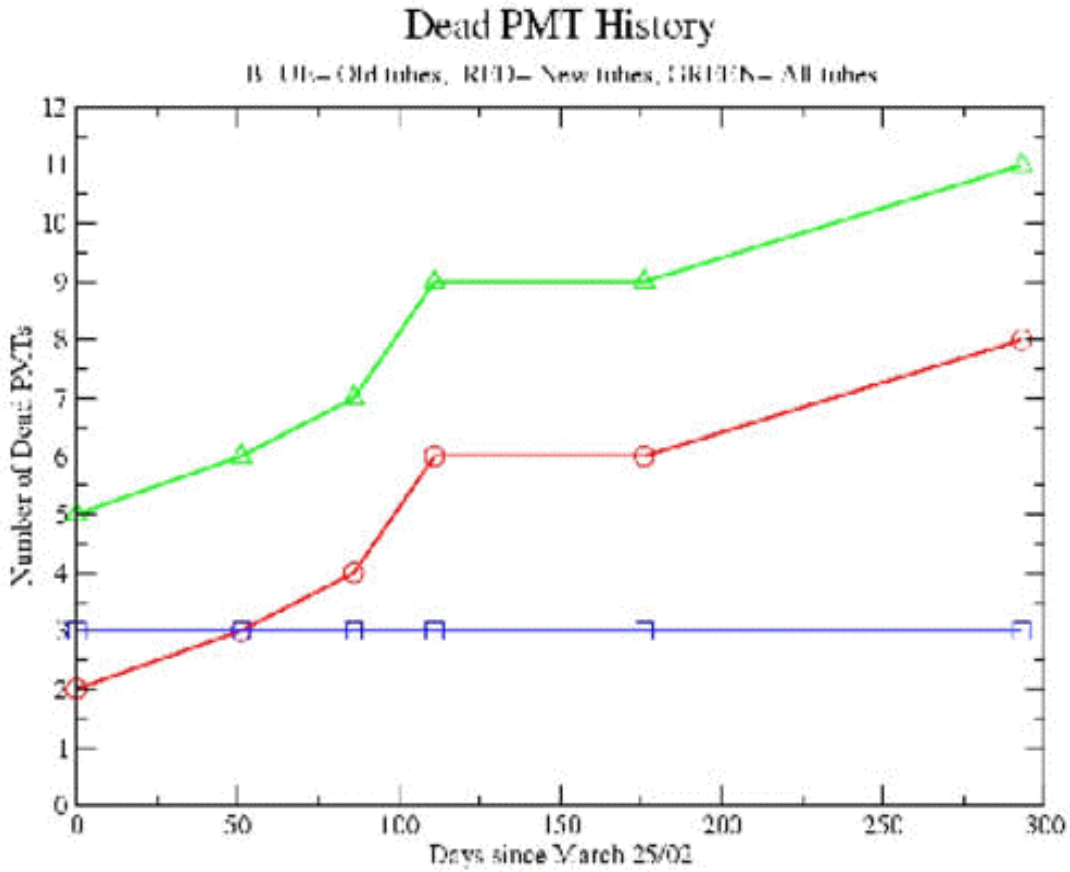
O_2/N_2 ratio



Electronics performance

- 99.5% operational electronics channels
- Dark noise ~ 1KHz
- 0.7% dead PMT's.

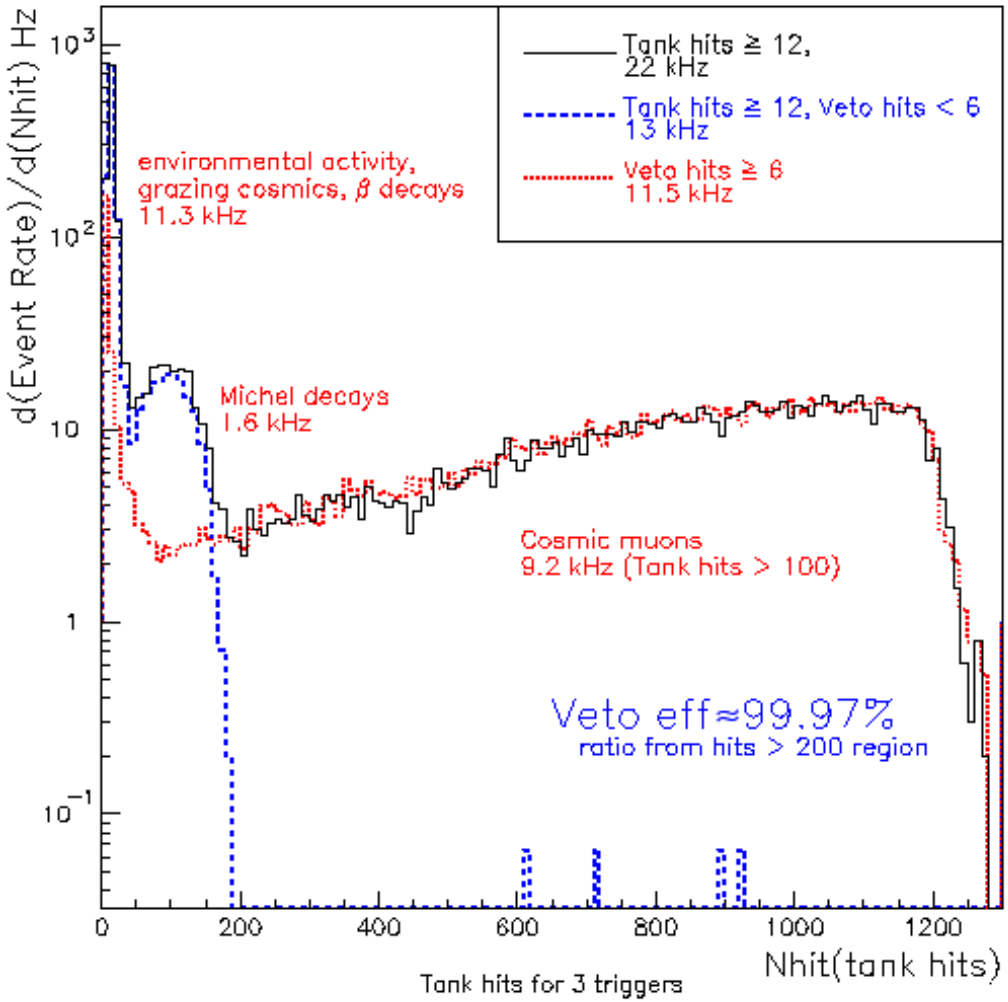
New PMT's dying at a rate of ~ 0.5%/yr



This is as good or better than other experiments!

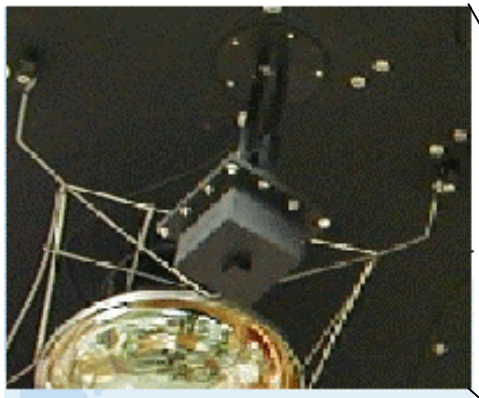
DAQ and Trigger

- Average trigger rate ~23 Hz
  Beam rate 2-5 Hz
- DAQ uptime ~ 98%
- Variety of internal triggers are implemented



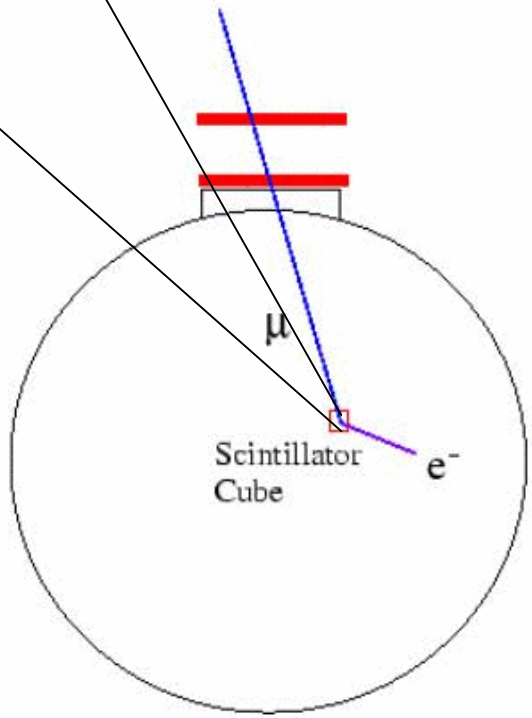
Calibration system

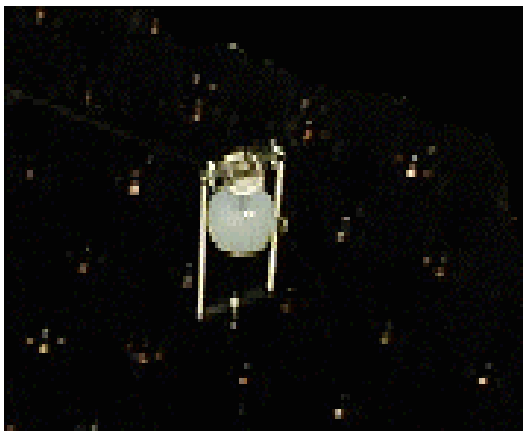
Cubes give position measurement of stopping muons and decay electrons



Cubes trigger implemented during Jan shutdown.
At the first order, trigger is working

Muon tracker provides direction of the cosmic ray muons

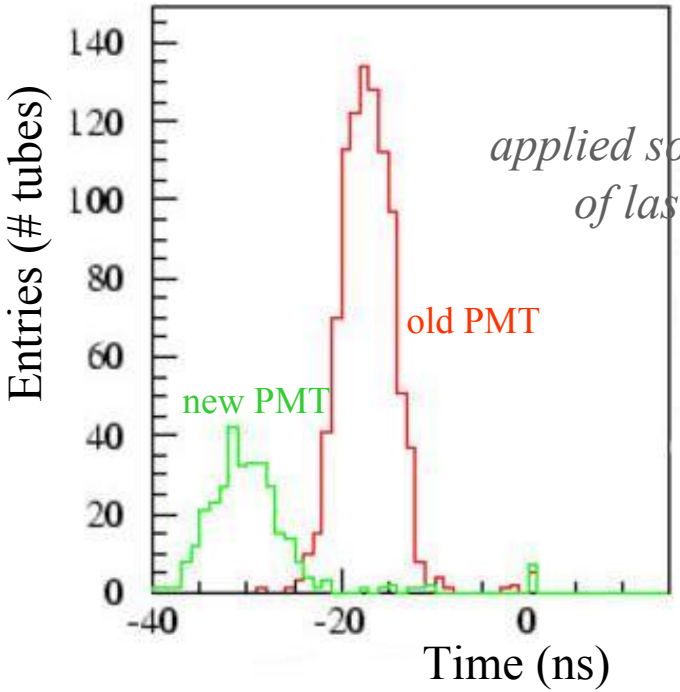




4 flasks filled with ludox
at different locations in the tank
Provide PMT gain and timing

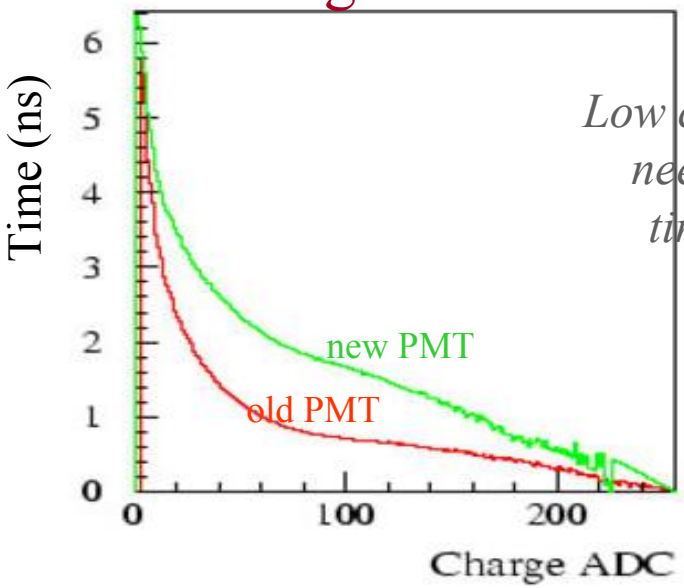
Calibration system: laser

Time offset constants



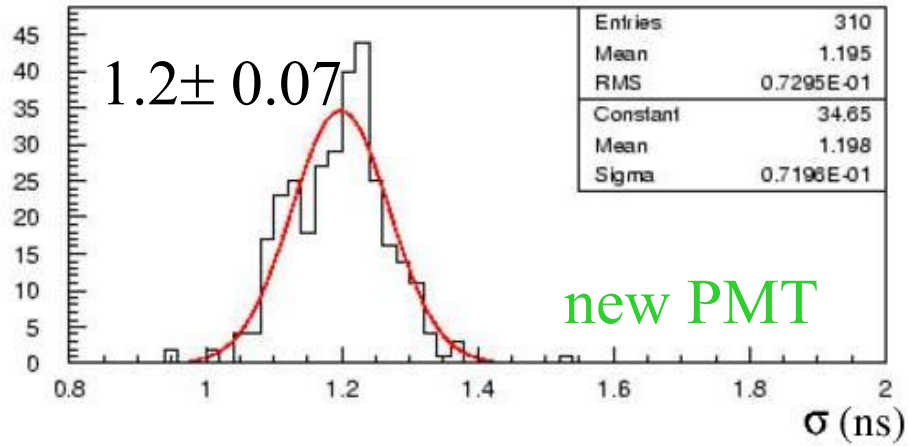
These values are applied so calibration time of laser hits is uniform across all tubes

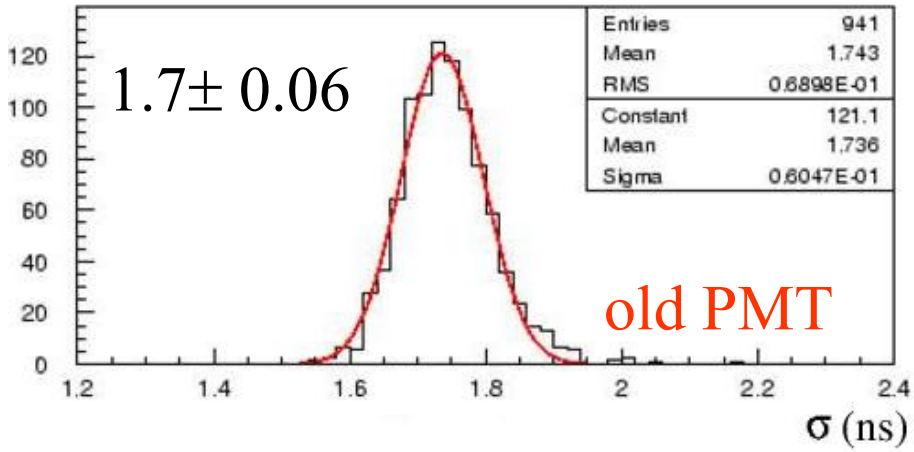
Time slewing constants



Low charge pulses need additional time correction

Single p.e.Timing Resolution



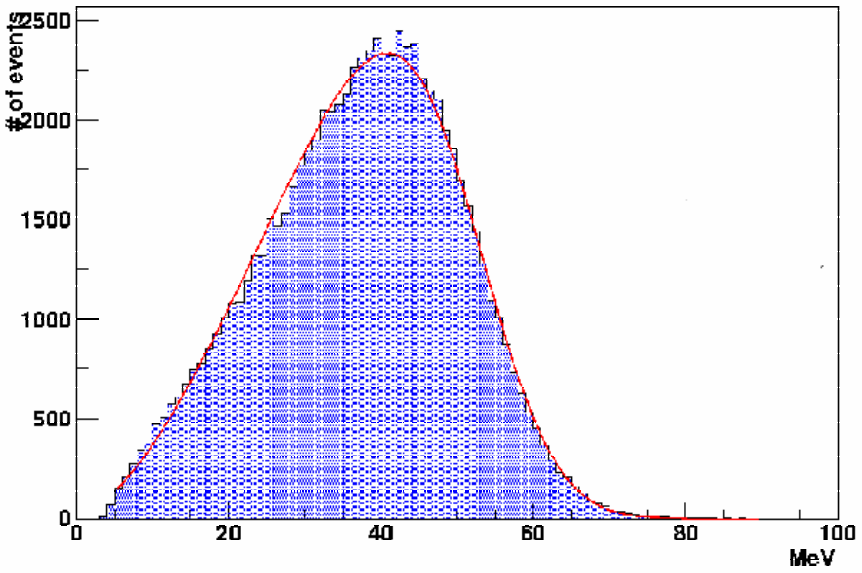


Good agreement with bench tests

Calibration:Michels

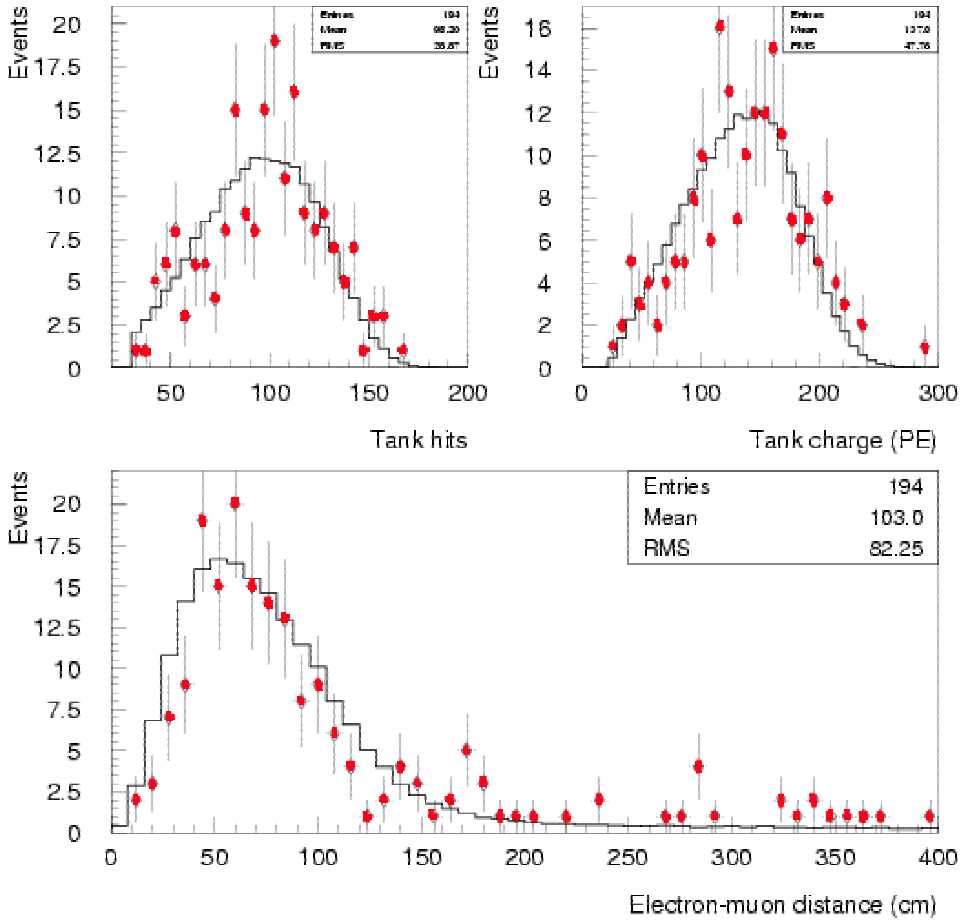
Using decay electrons from cosmic muons
to determine energy scale

Michel e^- energy spectrum

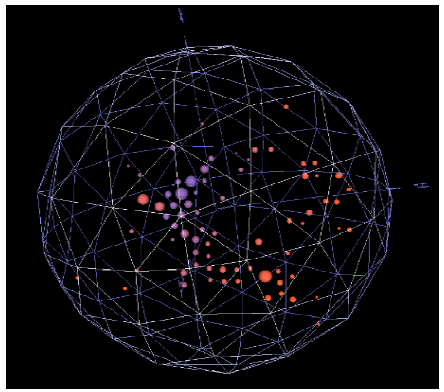


The end point indicates
14.8% energy resolution

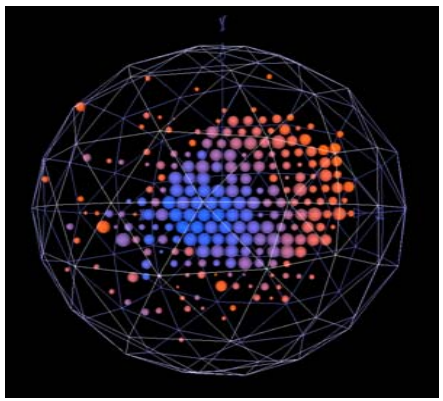
Michel and Monte Carlo comparison



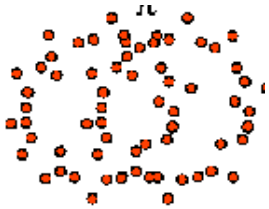
Events in the detector

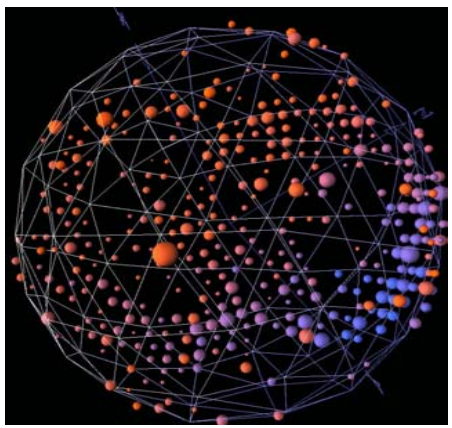


Muon candidate



Contained muon candidate



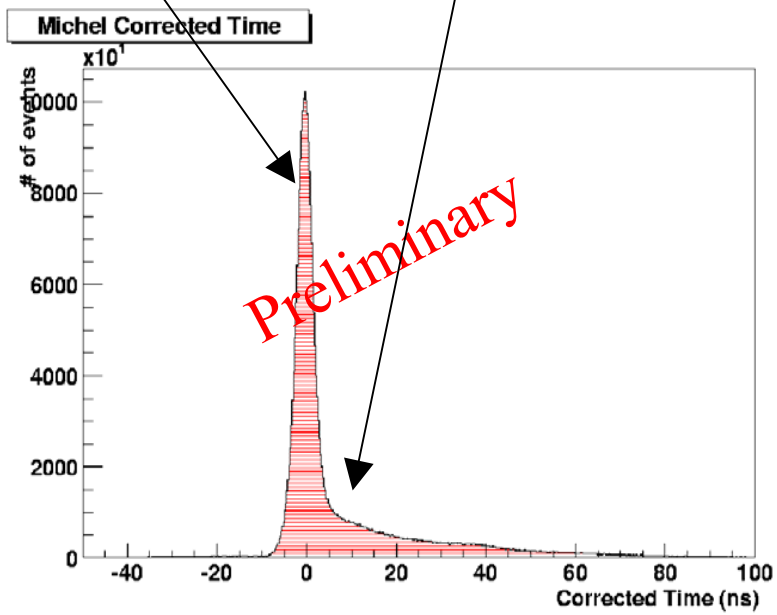


π^0 candidate

Neutrino interactions in oil produces

Cerenkov light (prompt)

Scintillation light (late)



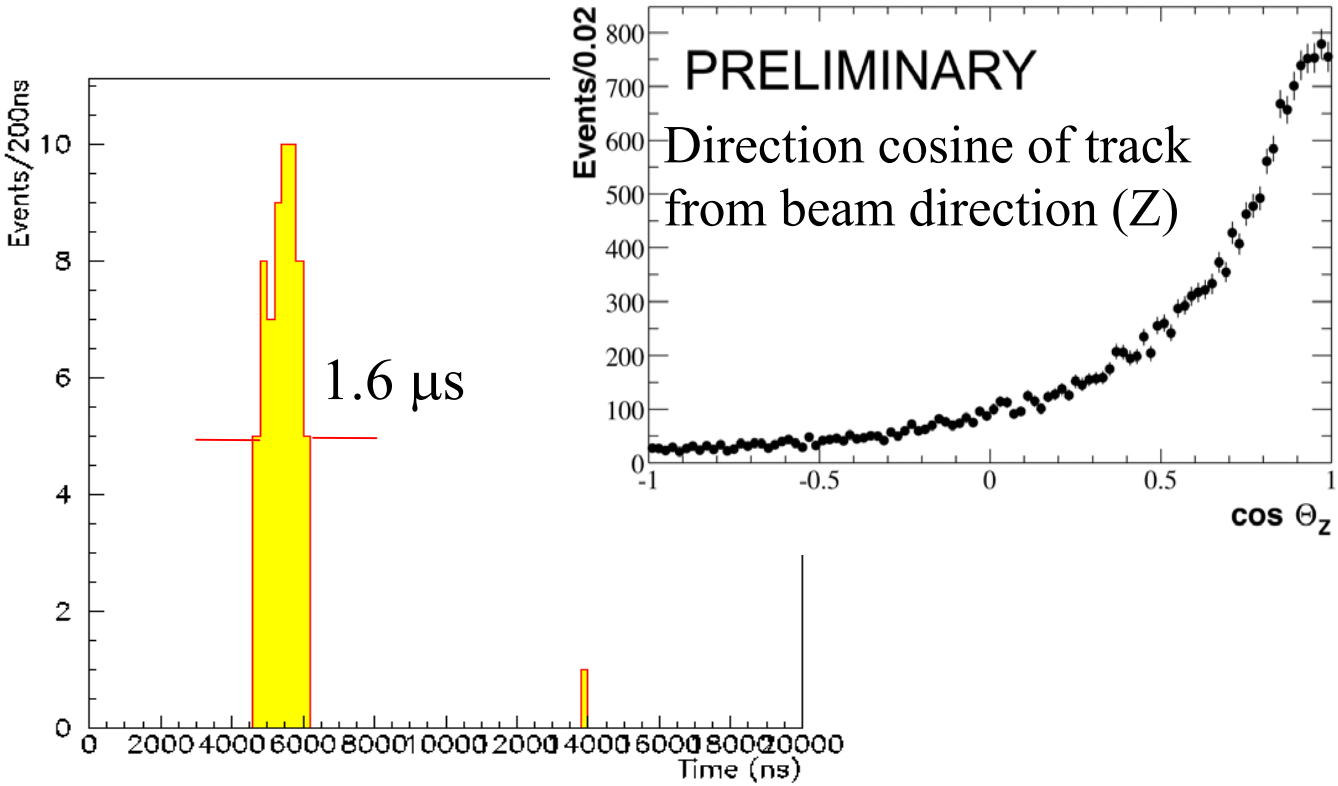
First events from beam data

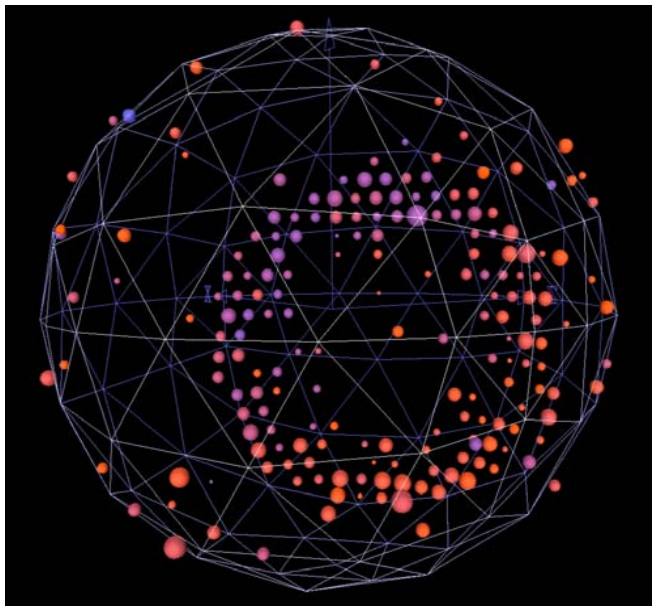
(Labor day weekend)

Simple cuts applied

> 200 hits in the main region

< 6 hits in the veto region



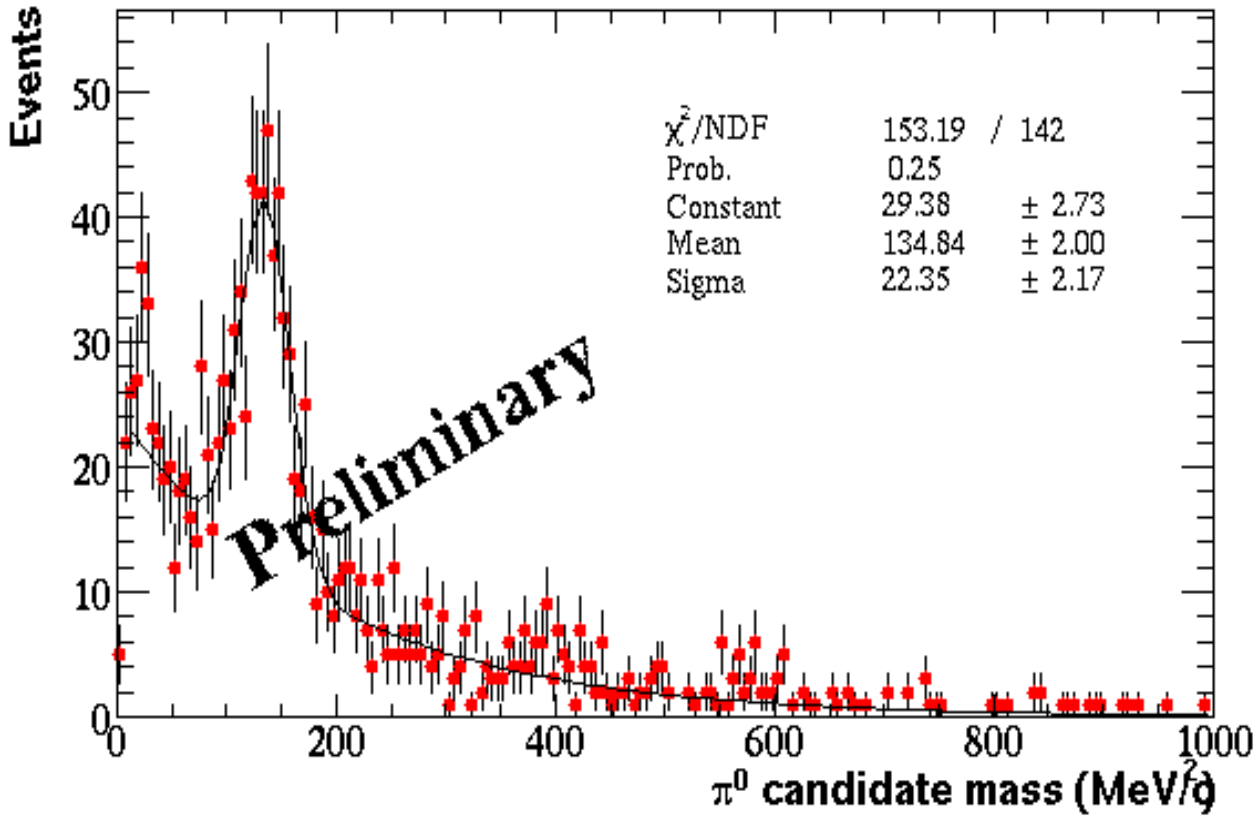


ν_μ CC candidate from the Labor day weekend

First look at π^0 mass ...and it is there!

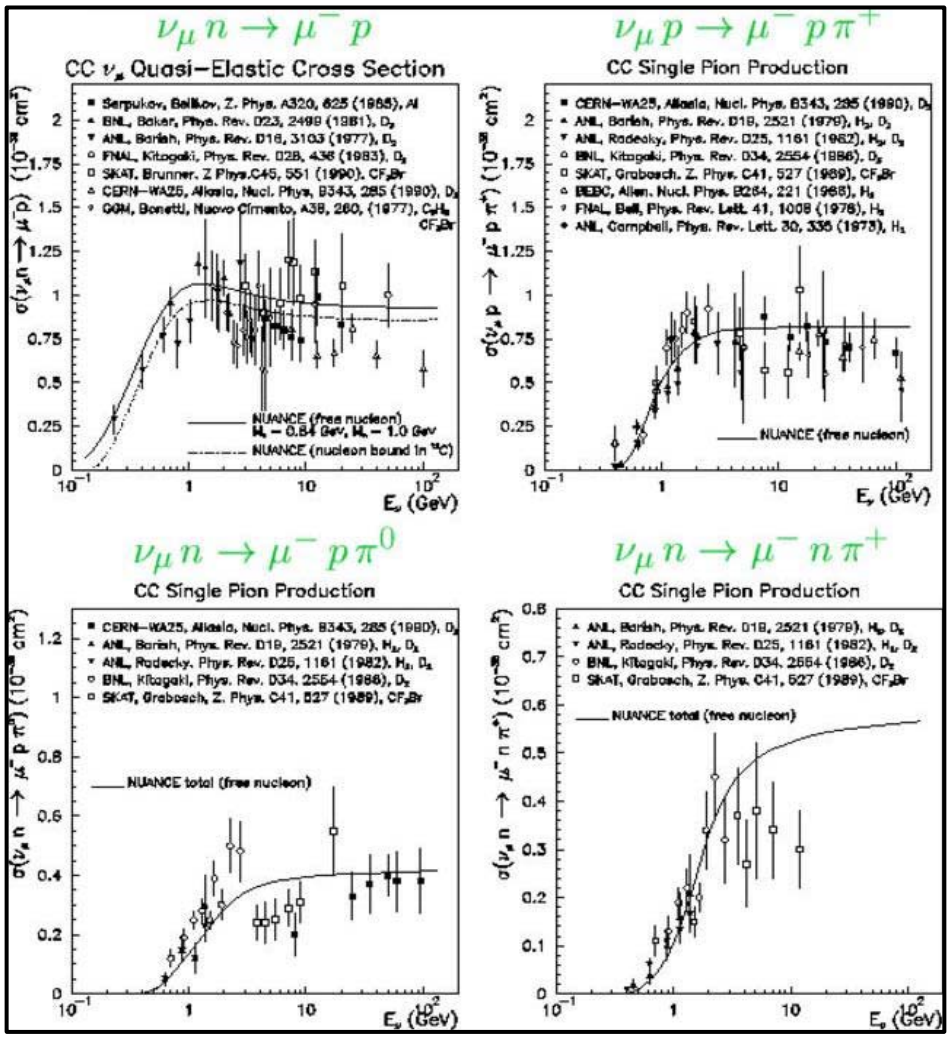
$\nu_\mu p \rightarrow \nu_\mu p \pi^0$
$\nu_\mu n \rightarrow \nu_\mu n \pi^0$ } π^0 NC production

Cuts applied:
- Tank hits >200
- Veto hits < 6
- 2 rings > 10 p.e. each
- 1.6 μs beam window



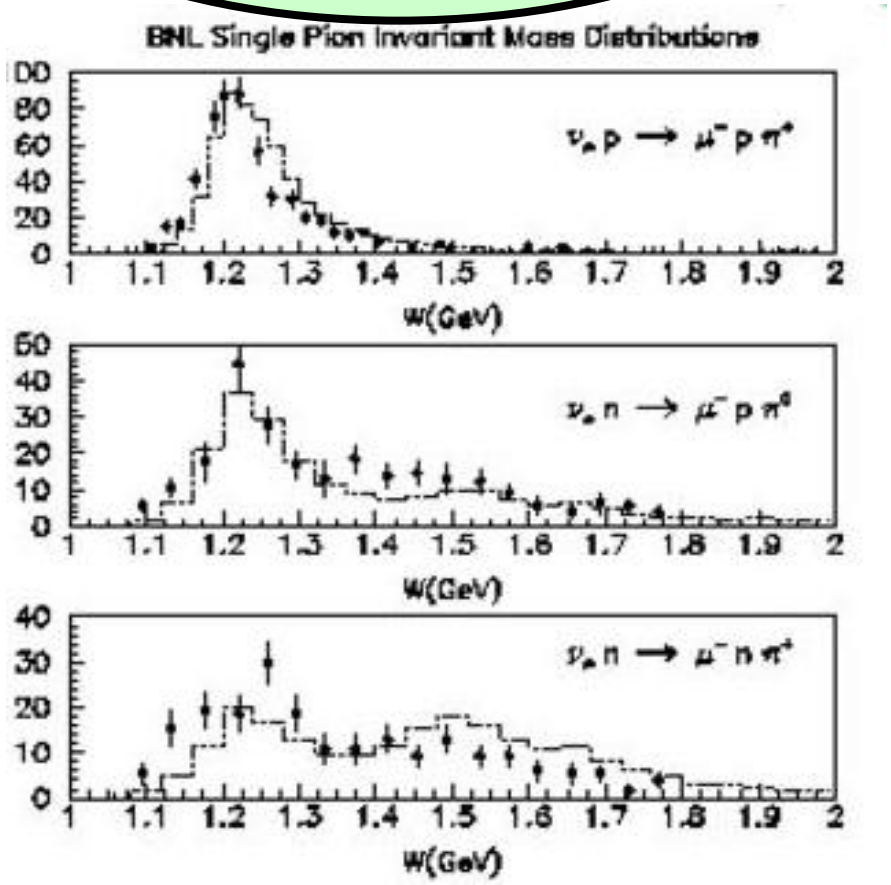
Using π^0 , we can check
the energy calibration
above michels

What do we know about low energy neutrinos cross sections?

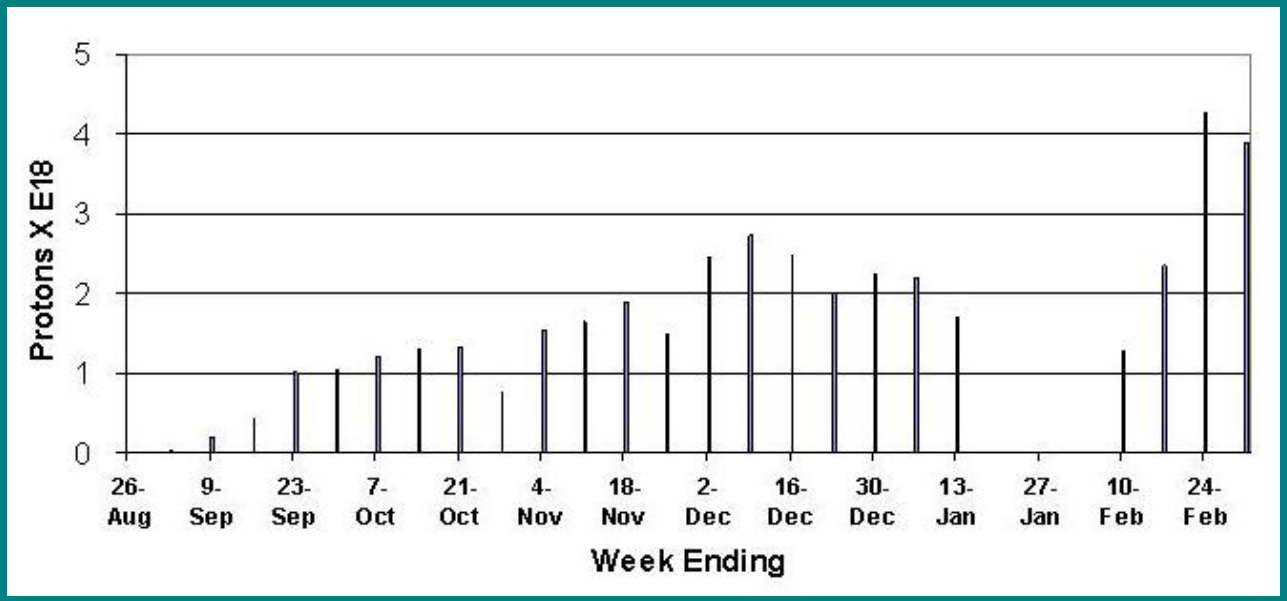


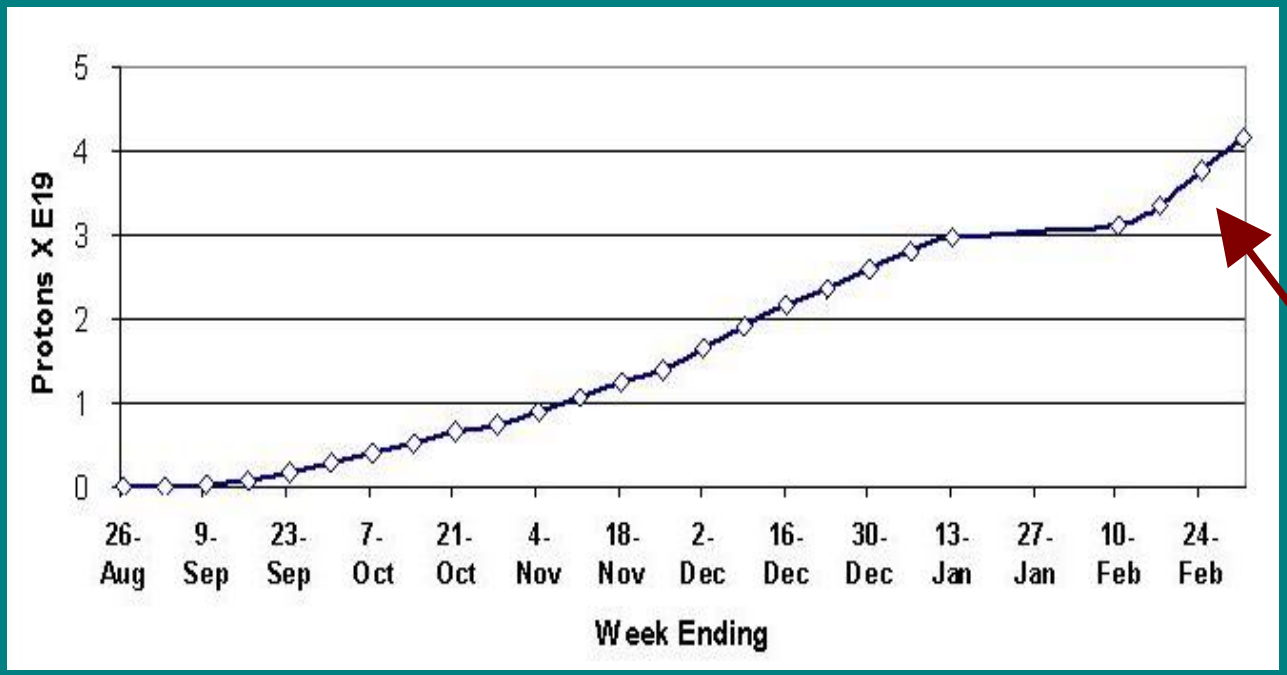
Check rates for various ν interactions

We collected ALL possible low energy neutrino data to check cross sections model and kinematics



And we are accumulating protons…





Record week:
Feb 24th with
4.28E18
protons delivered

Total protons delivered
4.16E19

~ 30% of the total protons delivered were collected after Jan shutdown.

Conclusions

- MiniBoone is taking data and is doing well!
- Neutrino events look as expected
- We are in the process of understanding our calibration and reconstruction algorithms
- Need more protons to complete the program